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Claims

[c1] 1.A method for processing a digital image, the method comprising:
estimating a foreground region relating to an imaged object;
estimating a background region relating to other than the imaged object; and
by using the image, the estimated foreground region and the estimated background region, calculating a transition region disposed between the foreground region and the background region;
wherein the estimated foreground region, the estimated background region, and the calculated transition region, each comprise a separate set of pixels that may each be processed separately for suppressing pixel intensities in the estimated background region and improving image quality.

[c2] 2.The method of Claim 1, wherein:
the estimating a foreground region comprises defining an initial foreground region as that region containing those pixels of the image meeting a first criterion; and
the estimating a background region comprises defining

the background region as that region containing those pixels of the image meeting a second criterion.

[c3] 3.The method of claim 2, wherein the first criterion comprises a pixel intensity greater than a first threshold.

[c4] 4.The method of claim 2, wherein the second criterion comprises a pixel intensity less than a second threshold.

[c5] 5.The method of claim 2, wherein the calculating a transition region comprises calculating the transition region as that region containing those pixels of the image meeting a third criterion.

[c6] 6.The method of Claim 5, wherein the third criterion comprises:
a pixel having a pixel intensity greater than the second threshold, a morphological connection to a foreground pixel, and a gradient magnitude that is within a gradient tolerance value of the gradient magnitude of the foreground pixel.

[c7] 7.The method of Claim 5, wherein the calculating a transition region further comprises:
iteratively calculating incremental transition regions, each having an incrementally larger gradient tolerance value, until a gradient tolerance value threshold is met or exceeded, wherein:

each incremental transition region is calculated to be that region containing pixels connected to a pixel of a previously calculated incremental transition region, having an intensity greater than the second threshold, and having a gradient magnitude that is within the incrementally larger gradient tolerance value of the gradient magnitude of the incremental transition region pixel to which it is connected.

[c8] 8.The method of Claim 7, wherein the calculating a transition region further comprises:
using a focus parameter to merge a defined number of the initial plus incremental transition regions into a single transition region.

[c9] 9.The method of Claim 8, further comprising:
defining an object region as the union of the initial foreground region and the single transition region, and performing at least one morphological operation on the object region.

[c10] 10.The method of Claim 9, further comprising:
defining a final foreground mask as the initial foreground region;
defining a final transition mask as the difference between the object region and the final foreground region; and

defining a final background mask as the remainder of the image.

[c11] 11.The method of Claim 8, further comprising:
suppressing pixel intensities in the background region by gradually reducing the intensity of background pixels to zero as a function of their distance from the object region.

[c12] 12.The method of Claim 11, wherein the function comprises a linear ramp function, an exponential function, a Gaussian function, a Hanning function, a Hamming function, any function for reducing a value with respect to distance, or any combination of functions comprising at least one of the foregoing functions.

[c13] 13.The method of Claim 5, further comprising:
defining an object region as the union of the initial foreground region and the initial transition region, and performing at least one morphological operation on the object region.

[c14] 14.The method of Claim 13, further comprising:
defining a final foreground mask as the initial foreground region;
defining a final transition mask as the difference between the object region and the final foreground region;

and
defining a final background mask as the remainder of the image.

[c15] 15.The method of Claim 14, further comprising:
suppressing pixel intensities in the background region by gradually reducing the intensity of background pixels to zero as a function of their distance from the object region.

[c16] 16.The method of Claim 15, wherein the function comprises a linear ramp function, an exponential function, a Gaussian function, a Hanning function, a Hamming function, any function for reducing a value with respect to distance, or any combination of functions comprising at least one of the foregoing functions.

[c17] 17.The method of Claim 1, wherein the digital image is a digital image of a biological object obtained using MR imaging, CT imaging, Ultrasound imaging, X-ray imaging, or any combination comprising at least one of the foregoing imaging processes.

[c18] 18.A computer program product for processing a digital image, the product comprising:
a storage medium, readable by a processing circuit, storing instructions for execution by the processing cir-

cuit for:

estimating a foreground region relating to an imaged object;

estimating a background region relating to other than the imaged object; and

by using the image, the estimated foreground region and the estimated background region, calculating a transition region disposed between the foreground region and the background region;

wherein the estimated foreground region, the estimated background region, and the calculated transition region, each comprise a separate set of pixels that may each be processed separately for suppressing pixel intensities in the estimated background region and improving image quality.

[c19] 19.The product of Claim 18, wherein:

the estimating a foreground region comprises defining an initial foreground region as that region containing those pixels of the image meeting a first criterion; and

the estimating a background region comprises defining the background region as that region containing those pixels of the image meeting a second criterion.

[c20] 20.The product of Claim 19, wherein the first criterion comprises a pixel intensity greater than a first threshold.

[c21] 21.The product of Claim 19, wherein the second criterion comprises a pixel intensity less than a second threshold.

[c22] 22.The product of Claim 21, wherein the calculating a transition region comprises calculating the transition region as that region containing those pixels of the image meeting a third criterion.

[c23] 23.The product of Claim 22, wherein the third criterion comprises:
a pixel having a pixel intensity greater than the second threshold, a morphological connection to a foreground pixel, and a gradient magnitude that is within a gradient tolerance value of the gradient magnitude of the foreground pixel.

[c24] 24.The product of Claim 23, further comprising instructions for execution by the processing circuit for:
defining an object region as the union of the initial foreground region and the initial transition region, and performing at least one morphological operation on the object region.

[c25] 25.The product of Claim 24, further comprising instructions for execution by the processing circuit for:
defining a final foreground mask as the initial fore-

ground region;
defining a final transition mask as the difference between the object region and the final foreground region; and
defining a final background mask as the remainder of the image.

[c26] 26.The product of Claim 25, further comprising instructions for execution by the processing circuit for:
suppressing pixel intensities in the background region by gradually reducing the intensity of background pixels to zero as a function of their distance from the object region.

[c27] 27.The product of Claim 26, wherein the function comprises a linear ramp function, an exponential function, a Gaussian function, a Hanning function, a Hamming function, any function for reducing a value with respect to distance, or any combination of functions comprising at least one of the foregoing functions.

[c28] 28.The product of Claim 23, wherein the calculating a transition region further comprises:
iteratively calculating incremental transition regions, each having an incrementally larger gradient tolerance value, until a gradient tolerance value threshold is met or exceeded, wherein:

each incremental transition region is calculated to be that region containing pixels connected to a pixel of a previously calculated incremental transition region, having an intensity greater than the second threshold, and having a gradient magnitude that is within the incrementally larger gradient tolerance value of the gradient magnitude of the incremental transition region pixel to which it is connected.

[c29] 29.The product of Claim 28, wherein the calculating a transition region further comprises:
using a focus parameter to merge a defined number of the initial plus incremental transition regions into a single transition region.

[c30] 30.The product of Claim 18, wherein the digital image is a digital image of a biological object obtained using MR imaging, CT imaging, Ultrasound imaging, X-ray imaging, or any combination comprising at least one of the foregoing imaging processes.